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# SEEDING REQUIREMENTS FOR SCANNING LASER VELOCIMETRY *

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## ABSTRACT

To measure the velocity distributions within time depenedent turbulent flow fields, a continuously scanning laser velocimeter system is being developed at SNLL. A prototype of this system has produced results which show that spatial and temporal variations in particle seed distribution seriously compromise the overall performance and operation of this device. To aileviate some of these problems, alternate flow seeding concepts have been explored. The most promising appear to be those that actively induce laser "sparks" within the gas flow, the velocity of which may be measured by a Fourier transformed velocimetry system.

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## OUTLINE:

### 1. Scanning Laser Velocimeter Configurations

Conventional Dual-Beam, three component
Multibeam - Fourier Transformed

### 2. Seeding Concepts Investigated

Passive: Conventional Pre-Mixed Systems
Active: In Situ Particle Seeding
In Situ Laser Induced Seeding

### 3. Data Processing Implications

## 1. Scanning Laser Velocimeter Configurations

### a) Conventional Dual-Beam Systems

Longitudinal Scanning
Transverse - Focal Plane Scanning

### b) Multibeam - Fourier Transformed Systems

Real Fringe
Virtual Fringe

### c) Data Processing Systems

Single processor
Multi-processor with virtual addressing

## a) Conventional Dual-Beam Velocimeter Systems

Longitudinal Scanning
    Zoom lenses, moving stages
Transverse Scanning - Focal Plane
    Rotating Planar Mirrors

### Advantages:

Commercial equipment is available
Large experience base for optics & processing

### Disadvantages:

Requires separate laser line for each component
Small depth of modulation within the fringe pattern
Unsatisfactory three component performance so far!

## b) Multibeam - Fourier Transformed Velocimeters

Longitudinal Scanning - Optical Axis
    Zoom lenses, stages
Transverse Scanning - Focal Plane
    Rotating Planar Mirrors

### Advantages:

Deep Fraunhofer Modulation - high Signal/Noise ratio
Only ONE laser beam need be used for 3 components

### Disadvantages:

Integrated commercial equipment is NOT available
Low absolute signal strength with current systems
Requires ELABORATE computer systems development

## 2. LV Seeding Concepts Investigated

### *Passive: Conventional Pre-mixed Seeding*

Particle/Aerosol Production Techniques
Spatial & Temporal Dispersion

### *Active: In Situ Particle Seeding*

Condensed & Solid Phase Particles
Chemically Formed Particles - $TiO_2$

### *Active: Laser Induced Phenomena*

Multiphoton Absorption
Breakdown - Laser Sparks

## *Passive: Conventional Pre-mixed LV Seeding*

| | |
|---|---|
| Atomizers - liquid droplets - polydispersed: | 0.5-2 microns |
| Berglund-Liu Aerosol Generator - monodispersed: | 1-40 microns |
| Pre-formed Particle Dispersers - monodispersed: | 1-10 microns |

### *Advantages:*

Good results obtained in homogeneously seeded flows
Integrated commercial equipment is available
Large experience base exists

### *Disadvantages:*

Difficult to achieve uniform concentrations in space & time
Low absolute data rates due to the stochastic nature
Performance of scanning LV systems is seriously compromised

## *Active: In Situ Particle LV Seeding*

Condensed liquid droplets formed from vapor/gas mixtures
Supercooled solid crystals formed from vapor/aerosol/gas mixes
Solid products from in situ vapor phase chemical reactions

### *Advantages:*

High local particle concentrations within interaction zones
Seed high speed accelerating flows without acoustic dispersion
Seed fine scale flows, e.g. porous membranes and surfaces

### *Disadvantages:*

Integrated commercial equipment is NOT available
Polydispersed, inhomogeneous in space & time - poor LV data
Difficult to characterize size & concentration of particles

## *Active: Laser Induced Seeding Phenomena*

### *Multiphoton Absorption:*

Pre-ionization condition, avalanche absorption
No emission, but scattering crossection enhanced

### *Breakdown - Laser Sparks:*

For air High E field > 6E+7 V/cm
at 1 atm.: High power density > 1E+5 MW/cm2
Laser: 900 mJ at 694.3 nm focused on spot 200 um dia.
Peak Power = 30MW, pulse duration = 30 ns, spark = 50us
Copper Vapor Lasers at 5kHz repetition rate

Advantages: Definitive scattering at high rates, with potential for molecular spectroscopy to determine density & temperture

Disadvantages: Additional excitation laser needed, with high power density optics required and constained velocity range

## *SUMMARY:*

### *Passive Seeding Techniques*

Conventional particle/aerosol seeding may be of limited value in any high rate scanning 3 component application

### *Active Seeding Technqiues*

Laser induced phenomena may be used to provide definitive scattering zones for LV and molecular spectroscopy

## Conclusion:

For high rate 3 dimensional scanning LV active seeding techniques should be used to produce uniform scattering zones in space and time.